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MODIS Spatial Calibration – Methodology and On-orbit Performance

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Abstract - The Moderate Resolution Imaging Spectroradiometer (MODIS) has 36 spectral bands, a total of 490 detectors, located on four focal plane assemblies (FPAs): visible (VIS), near infrared (NIR), short- and mid-wave infrared (SMIR), and long-wave infrared (LWIR). Nearly identical copies of the MODIS have been operating on-board the Earth Observing System (EOS) Terra spacecraft launched in December 1999 and the EOS Aqua spacecraft launched in May 2002, providing continuous data products for the studies of both short- and long-term changes in the global environment. In addition to the sensor's radiometric calibration, the band-to-band registration (BBR) is an important parameter needed to correctly interpret and analyze sensor images and data products derived from multiple spectral bands. MODIS has an on-board spectro-radiometric calibration assembly (SRCA) that can be used for the instrument spatial characterization. This paper describes MODIS on-orbit BBR measurement by the SRCA and the methodologies of computing the BBR in the along-scan and along-track directions. The Terra MODIS BBR trending results derived from its on-orbit measurements over 4 years are provided to illustrate the sensor's spatial performance as well as its on-board SRCA.

1. Introduction

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a milestone instrument for the NASA's Earth Observing System (EOS), designed to take measurements in the spectral regions that have been used in previous satellite sensors and to improve our understanding of the Earth system by extending data sets of heritage sensors. The MODIS proto-flight model (PFM) on the EOS Terra spacecraft was launched on December 18, 1999 and its flight model 1 (FM1) on the EOS Aqua was launched on May 4, 2002. Since their launch, the two MODIS instruments, with Terra operated in a 10:30am (morning) orbit and Aqua in a 1:30pm (afternoon) orbit, have been producing continuous and complementary global data sets for a broad range of applications, including land and cloud boundaries, ocean color, surface temperature, and atmospheric properties[1-5].

MODIS is a cross-track scanning radiometer that uses a double-sided scan mirror, making Earth observations over a wide field-of-view (FOV) of ±55° relative to the instrument nadir. It has 36 spectral bands with wavelengths from 0.41 to 14.5μm and spatial (nadir) resolutions of 250m (bands 1-2), 500m (bands 3-7), and 1km (bands 8-36).

The 250m, 500m, and 1km resolution bands have 40, 20, and 10 detectors per band, respectively, aligned in the along-track direction. Bands 13 and 14 collect data with both high and low gains through time-delay and integration (TDI) by a pair of 10 detectors each. Thus MODIS has a total of 490 detectors. These bands/detectors are located on four focal plane assemblies (FPAs) according to their spectral regions: visible (VIS), near infrared (NIR), short- and mid-wave infrared (SMIR), and long-wave infrared (LWIR). The VIS and NIR are operated at instrument ambient temperature while the SMIR and LWIR are normally controlled at 83K using a passive radiative cooler assembly.

Bands 1-19 and 26, with wavelengths from 0.41μm to 2.2μm, are the reflective solar bands (RSB) that are calibrated on-orbit by a solar diffuser (SD) and a solar diffuser stability monitor (SDSM) system. Bands 20-25 and 27-36, with wavelengths from 3.5 to 14.5μm, are the thermal emissive bands (TEB) that are calibrated by a blackbody (BB). In addition to the radiometric calibration, the MODIS instrument has a unique on-board device called the spectro-radiometric calibration assembly (SRCA). The SRCA is an instrument within the MODIS instrument that can be used for the spatial and spectral characterization[6-8].

The radiometric and spectral calibration topics are discussed in two separate papers that also appear in the these proceedings[9,10]. We focus, in this paper, on the MODIS spatial calibration by examining its on-orbit band-to-band registration (BBR) change. The BBR is an important parameter needed for the images and data products derived from multiple spectral bands in a single sensor or multiple sensors. When the SRCA is configured into spatial mode, it is capable of measuring the BBR in along-scan direction for each detector and in along-track direction for each band. To the best of our knowledge, it is the first time that a satellite imaging spectral radiometer has been equipped with such a device that could make extensive spatial and spectral characterization of the instrument on-orbit. This paper describes the BBR measurement methodology using the on-board SRCA, and presents the BBR trending results of Terra MODIS from its on-orbit observations over last 4 years.